Improving our Measures of Incremental Progress for Clean and Safe Water

EPA Region III/Office of Water Review – June 16 2015

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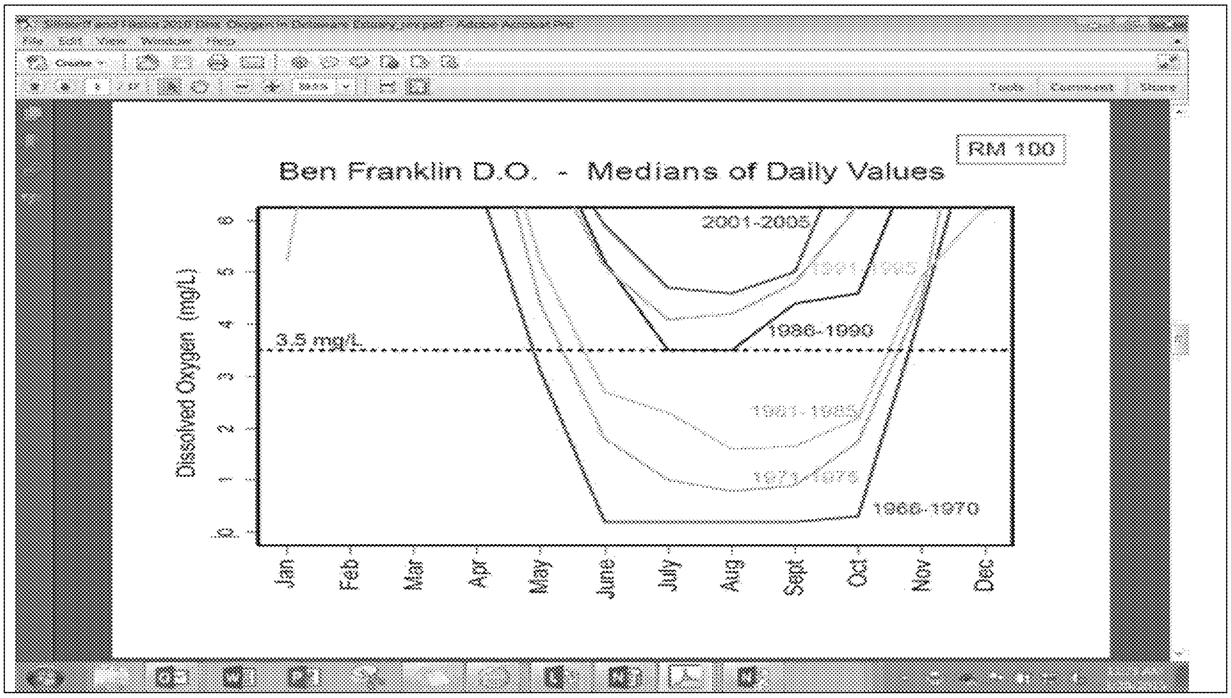
Region 3 Case Examples

- Delaware River DO and PCB Trends
- Mirror Lake Progress Story in DE
- West Virginia Long term Trends Analysis
- Chesapeake Bay Barometer (WQ)

Insert DE River Slides Here

- Slides 1, 8, 9,10,11,12,13,14, 15,17, 20
- DO and PCB charts

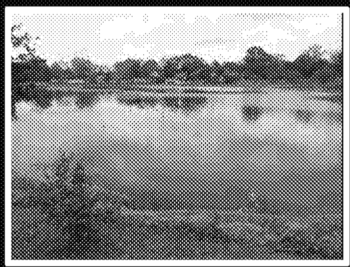


RM 100
Ben Franklin D.O. - Medians of Daily Values
Dissolved Oxygen (mg/L)
0
1
2
3
4
5
6
3.5 mg/L
2001-2005
1991-1995
1986-1990
1981-1985
1971-1975
1966-1970
Jan
Feb
Mar
Apr
May
June
July
Aug
Sept
Oct
Nov
Dec

Stories of Progress
in Achieving Healthy Waters

MIRROR LAKE REFLECTS 'SIGNIFICANT IMPROVEMENT'

Dover, DE



Delaware reports a 60 percent baseline reduction of contaminants in fish, water and sediment one year after an EPA-aided restoration project at Mirror Lake in Dover, Delaware.

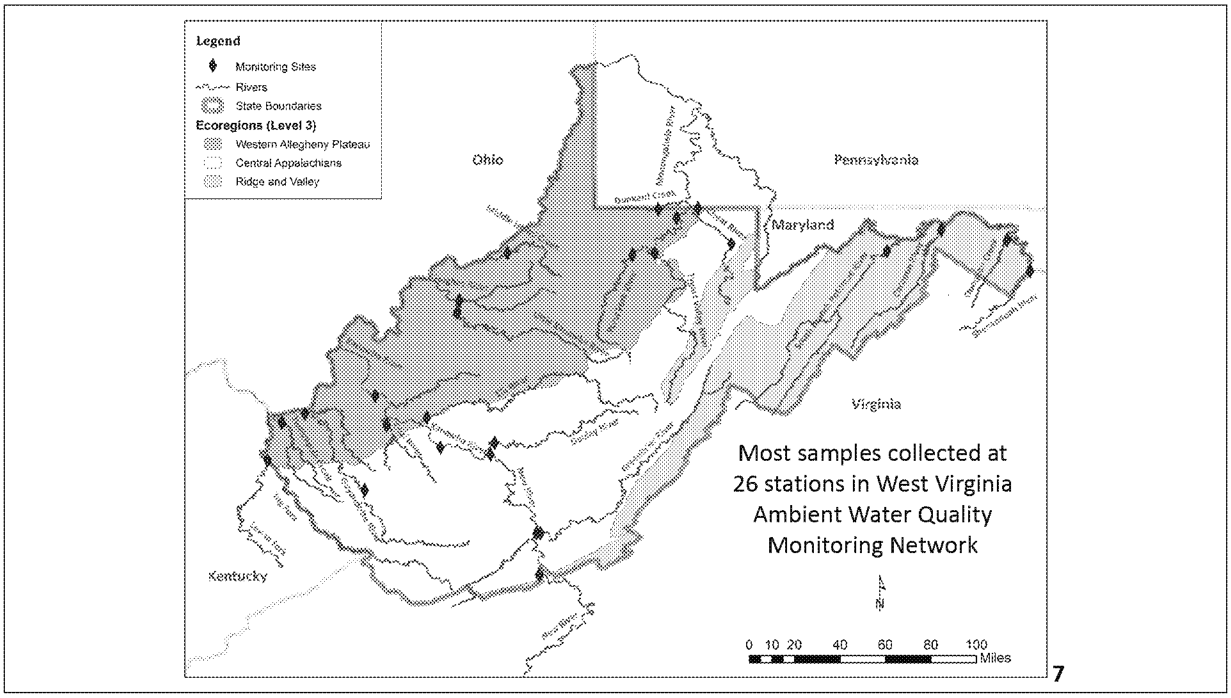
http://intranet.epa.gov/r3intran/wpd/success_stories.html

West Virginia water quality trend analysis

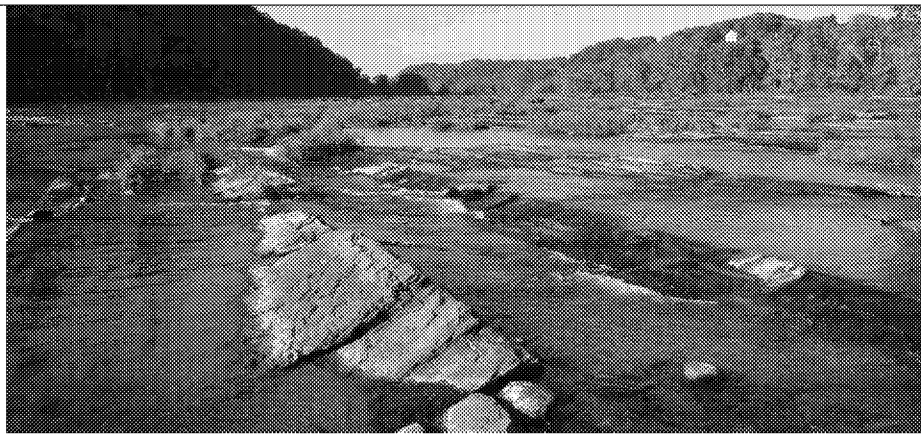
EPA Region III/State and Interstate Water Directors Meeting
Washington, DC

April 29-30, 2015

Claire Buchanan and Ross Mandel
Interstate Commission on the Potomac River Basin



The twenty-six (26) AWQM stations are located at or near the mouths of the state's larger rivers or situated so as to isolate the impacts of major industrial complexes and other potential sources of impairment. They are now sampled bi-monthly (six times a year).



Shenandoah near confluence with Potomac River, by Adam Griggs

Can long-term trends be identified?

Does flow-adjustment strengthen trend detection?

Are there regional trend patterns?

Can we explain those patterns?

WVDEP approached ICPRB about performing long-term trend analyses on selected parameters in their database. They wanted trend analyses and a report comparable to those done in 2008 by ORSANCO for Ohio River mainstem stations. They originally wanted to know if:

long-term trends could be identified in 22 water quality parameters;

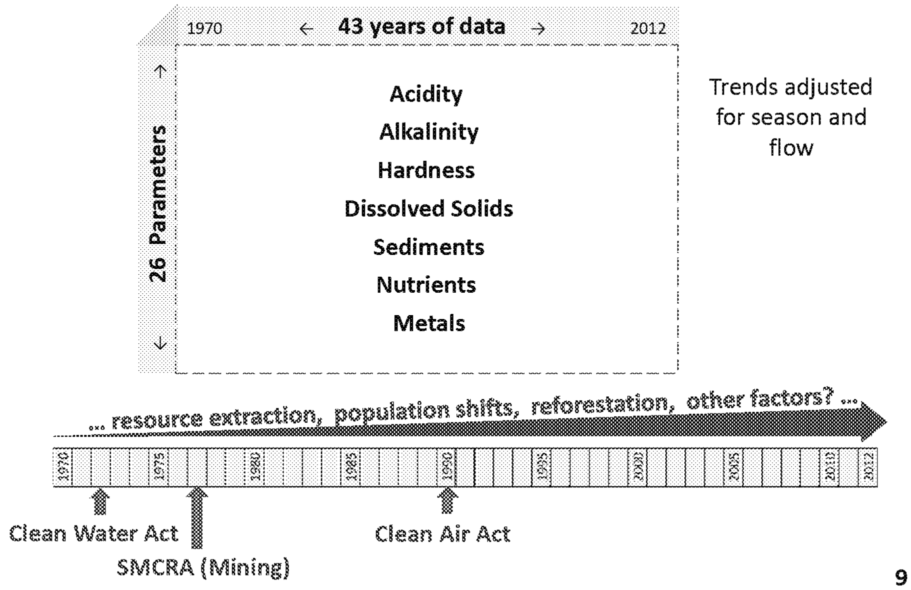
flow-adjustment strengthened those trends by removing flow effects;

trend patterns occurred state-wide or within specific regions of the state; and

there possible explanations for the observed patterns in long-term trend.

The analyses are complete and the report is final.

Final Data Set for Long-Term Trend Analysis by ICPRB



pH (Acidity)

Region	Station	StreamName	Decreasing H^+ ↘ pH	Sulfate (SO_4)	Nitrate/ Nitrite
Western Allegheny Plateau	KC-00001-11.6	Coal River	▲	▲	▲
	ML-00001-20.6	Dunkard Creek	▲	▲	ns
	KE-00001-4.3	Elk River	▲	▲	ns
	OGL-00001-2.8	Guyandotte River (Lower)	▲	ns	▲
	LK-00025-1.5	Hughes River	▲	▿	-
	KL-00001-31.7	Kanawha River (Lower)	▲	ns	ns
	LK-00001-28.9	Little Kanawha River	-	▽	▽
	OMN-00006-12.3	Middle Island Creek	▲	▽	▽
	MU-00001-99.4	Monongahela River (Upper)	▲	▽	ns
	BST-00001-0.15	Tug Fork	▲	▲	▲
	MT-00001-6.2	Tygart Valley River	▲	▿	▽
	MW-00001-12	West Fork River	▲	▽	ns
Central Appalachians	MC-00001-30	Cheat River	▲	▽	▽
	KG-00001-8.25	Gauley River	▲	▲	▽
	KNG-00001-1.6	Greenbrier River	▲	ns	▽
	KU-00001-74.1	Kanawha River (Upper)	▲	▲	▿
	KN1-00001-1.2	New River (Lower)	▲	▿	ns
	KNU-00001-67.4	New River (Upper)	▲	ns	▲
	KNU-00001-96.2	New River (Upper)	▲	ns	▵
Ridge & Valley	PU-00010-6.1	Cacapon River	▵	▽	▿
	PL-00014-2.2	Opequon Creek	ns	▲	▿
	PSB-00001-13.4	South Branch Potomac River	▲	▽	ns
	PS-00001-0.9	Shenandoah River	ns	▽	ns

Principal components of acid rain

Upward pH (decreasing H^+) trends are not matched by consistent downward trends in SO_4 and NO_x

.: Acid rain abatement does not directly explain regional increasing pH trends

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The almost universal upward trends in stream and river pH suggest atmospheric reductions are at least partially responsible for the increasing trends in water pH. Atmospheric deposition of NOx and SO4 (acid rain) , the two major components of atmospheric deposition and acid rain, is a large cause of stream and river acidification. The 1990 Clean Air Act and successive regulations have successfully reduce atmospheric deposition of NOx and SO4.

Finding: SO4 and Nox are not decreasing universally at WV stations – some even are showing significant increasing trends.

Reductions in atmospheric deposition probably does not directly explain the regional upward trends in pH, and other sources and sinks of SO4 and NOx are active.

Acidity and Alkalinity

Decreasing H⁺ ↘

Ecoregion	Station	StreamName	pH	Alkalinity
Western Allegheny Plateau	KC-00001-11.6	Coal River	▲	▲
	ML-00001-20.6	Dunkard Creek	▲	▲
	KE-00001-4.3	Elk River	▲	▲
	OGL-00001-2.8	Guyandotte River (Lower)	▲	▲
	LK-00025-1.5	Hughes River	▲	▲
	KL-00001-31.7	Kanawha River (Lower)	▲	▲
	LK-00001-28.9	Little Kanawha River	▴	▲
	OMN-00006-12.3	Middle Island Creek	▲	▲
	MU-00001-99.4	Monongahela River (Upper)	▲	▲
	BST-00001-0.15	Tug Fork	▲	▲
	MT-00001-6.2	Tygart Valley River	▲	▲
	MW-00001-12	West Fork River	▲	▲
Central Appalachians	MC-00001-30	Cheat River	▲	▲
	KG-00001-8.25	Gauley River	▲	▲
	KNG-00001-1.6	Greenbrier River	▲	▴
	KU-00001-74.1	Kanawha River (Upper)	▲	▲
	KNL-00001-1.2	New River (Lower)	▲	▴
	KNU-00001-67.4	New River (Upper)	▲	▲
	KNU-00001-95.2	New River (Upper)	▲	▲
Ridge & Valley	PU-00010-6.1	Cacapon River	▴	ns
	PL-00014-2.2	Opequon Creek	ns	▲
	PSB-00001-13.4	South Branch Potomac River	▲	ns
	PS-00001-0.9	Shenandoah River	ns	ns

Alkalinity is bases:

Carbonate CO_3^{2-}

Bicarbonate HCO_3^-

Phosphate PO_4^{3-}

Hydroxyl OH^-

borates, silicates, and other bases

Increasing alkalinity *reduces* free H⁺ ions

which *increases* pH

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The region-wide increase in pH (decrease in H+) is coincidental with a similar rise in alkalinity. Could this explain the pH pattern?

Alkalinity measures the buffering capacity of water, or its ability to neutralize acids. Alkalinity is mostly comprised of bases. Types of bases: primarily carbonate (CO32-) and bicarbonate (HCO3-) but also phosphate (PO43-), hydroxyl (OH-), borates, silicates, and other bases—that are available to bind with free cations, including H+.

The broad increasing trends in West Virginia alkalinity closely parallel the increasing pH trends. They are comparable to those documented by Kaushal et al. (2013) for 62 of 97 other eastern U.S. rivers and streams. Kaushal et al. proposed that the increasing alkalinity trends were largely related to "human-accelerated chemical weathering [acid deposition], in addition to … mining and land use." In other words, acid rain can increase the chemical weathering of rocks & cement-based materials, causing bases to be released which increases alkalinity and the buffering capacity of surface waters, which in turn usually reduces H+ ions (increases pH).

Acid rain could be indirectly countering its direct, acidification effect on surface waters.

Note again - 3 of 4 trends in Ridge & Valley ecoregion are ns.

Metals

Region	Station	StreamName	Aluminum	Iron	Manganese	Lead	Zinc
Western Allegheny Plateau	KC-00001-11.6	Coal River	▽	▽	▽	-	ns
	ML-00001-20.6	Dunkard Creek	▽	▿	▽	▽	ns
	KE-00001-4.3	Elk River	▽	▿	▿	ns	ns
	OGL-00001-2.8	Guyandotte River (Lower)	▽	▽	▽	▽	ns
	LK-00025-1.5	Hughes River	-	▽	▽	ns	ns
	KL-00001-31.7	Kanawha River (Lower)	▽	▽	▽	▽	ns
	LK-00001-28.9	Little Kanawha River	▿	ns	ns	▿	ns
	OMN-00006-12.3	Middle Island Creek	ns	ns	▽	▿	ns
	MU-00001-99.4	Monongahela River (Upper)	▽	▽	▽	▽	▽
	BST-00001-0.15	Tug Fork	▽	▿	▽	▽	ns
	MT-00001-6.2	Tygart Valley River	-	▿	▽	▽	▴
	MW-00001-12	West Fork River	▽	▽	▽	▽	▽
Central Appalachians	MC-00001-30	Cheat River	▽	▽	▽	▽	▿
	KG-00001-8.25	Gauley River	▽	▽	▽	▴	ns
	KNG-00001-1.6	Greenbrier River	ns	▽	▿	▿	ns
	KU-00001-74.1	Kanawha River (Upper)	▽	▽	▽	▽	▲
	KNL-00001-1.2	New River (Lower)	▽	▿	▽	▿	ns
	KNU-00001-67.4	New River (Upper)	▽	▽	▽	▿	▴
	KNU-00001-96.2	New River (Upper)	▽	▽	▽	▽	ns
Ridge & Valley	PU-00010-6.1	Cacapon River	▽	▿	▿	▿	▿
	PL-00014-2.2	Opequon Creek	ns	ns	▽	▽	ns
	PSB-00001-13.4	South Branch Potomac River	▽	▽	▽	▽	ns
	PS-00001-0.9	Shenandoah River	▽	▽	▽	▽	ns

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Regardless of what caused pH levels to rise state-wide, the higher pH levels (i.e., lower H+ concentrations) would have increased the tendencies of several dissolved metals (Al, Fe, Mn, Pb) to precipitate and ultimately lowered their concentrations in the water column. This would have helped any human efforts to reduce concentrations of these particular metals. Good news

No state-wide trend pattern in zinc.

Indicators of Eutrophication

Region	Station	StreamName	Total Susp. Solids (TSS)	Total Phosphorus	Nitrate/ Nitrite	Fecal Coliform
Western Allegheny Plateau	KC-00001-11.6	Coal River	▽	▽	▲	▽
	ML-00001-20.6	Dunkard Creek	▽	▽	ns	▿
	KE-00001-4.3	Elk River	▽	▽	ns	ns
	OGL-00001-2.8	Guyandotte River (Lower)	▽	▽	▲	▽
	LK-00025-1.5	Hughes River	▽	▽	-	ns
	KL-00001-31.7	Kanawha River (Lower)	▽	▽	ns	▿
	LK-00001-28.3	Little Kanawha River	▿	▿	▽	ns
	OMN-00006-12.3	Middle Island Creek	▽	▽	▽	▿
	MU-00001-99.4	Monongahela River (Upper)	▽	▽	ns	▽
	BST-00001-0.15	Tug Fork	▽	▽	▲	▽
	MT-00001-6.2	Tygart Valley River	▽	▽	▽	ns
	MW-00001-12	West Fork River	▽	▽	ns	▿
Central Appalachians	MC-00001-30	Cheat River	▽	▽	▽	▲
	KG-00001-8.25	Gauley River	▽	▽	▽	ns
	KNG-00001-1.6	Greenbrier River	▽	▽	▽	▿
	KU-00001-74.1	Kanawha River (Upper)	▽	▽	▿	▽
	KNL-00001-1.2	New River (Lower)	▽	▽	ns	▽
	KNU-00001-67.4	New River (Upper)	▽	-	▲	ns
	KNU-00001-96.3	New River (Upper)	▽	▽	▵	▽
Ridge & Valley	PU-00010-6.1	Cacapon River	▽	▿	▿	▲
	PL-00014-2.2	Opequon Creek	▽	▿	▿	▲
	PSB-00001-13.4	South Branch Potomac River	▽	ns	ns	ns
	PS-00001-0.9	Shenandoah River	▽	▽	ns	ns

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Nitrate-Nitrate-N is usually the largest component of total nitrogen (TN) and another strong indication of human disturbance. Trends in Nitrate-Nitrate-N are mixed – five increasing, nine decreasing and seven showing no trend.

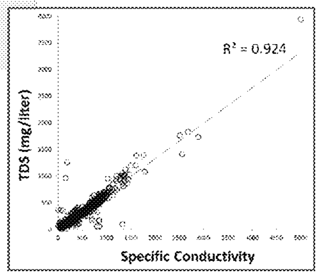
Fecal coliform is an indication of human and animal waste
Trends are mixed - generally downward in Western Allegheny Plateau and Central Appalachians but two of the four Potomac tribs in WV are trending upward – reflects development?

For these parameters, site-specific analyses will better inform us about causes of trends

Dissolved Solids and Conductivity

Region	Station	StreamName	Total Diss. Solids (TDS)	Specific Conductance
Western Allegheny Plateau	KC-00001-11.6	Coal River	▲	▲
	ML-00001-20.5	Dunkard Creek	▲	▲
	KE-00001-4.3	Elk River	▲	▲
	OGL-00001-2.8	Guyandotte River (Lower)	▴	ns
	LK-00025-1.5	Hughes River	ns	ns
	KL-00001-31.7	Kanawha River (Lower)	▴	▴
	LK-00001-28.9	Little Kanawha River	ns	ns
	OMN-00005-12.3	Middle Island Creek	ns	ns
	MU-00001-99.4	Monongahela River (Upper)	ns	▴
	BST-00001-0.15	Tug Fork	▲	▲
	MT-00001-6.2	Tygart Valley River	▲	▴
	MW-00001-12	West Fork River	▽	▽
Central Appalachians	MC-00001-30	Cheat River	ns	▿
	KG-00001-8.25	Gauley River	▲	▲
	KNG-00001-1.6	Greenbrier River	▴	ns
	KU-00001-74.1	Kanawha River (Upper)	▲	▲
	KNL-00001-1.2	New River (Lower)	▲	▴
	KNU-00001-57.4	New River (Upper)	▲	▲
	KNU-00001-96.2	New River (Upper)	▲	▲
Ridge & Valley	PU-00010-6.1	Cacapon River	ns	ns
	PL-00014-2.2	Opequon Creek	▲	▲
	PSB-00001-13.4	South Branch Potomac River	▲	▲
	PS-00001-0.9	Shenandoah River	▽	▿

Very **strong** relationship between TDS and conductivity



Trends in dissolved solids and conductivity are mixed, with more stations trending upward (degrading) rather than downward (improving).

TDS and conductivity are closely related parameters.
TDS measures the amount of chemicals dissolved in water – most of which have an electrical charge.
Conductivity measures the electrical current that can pass through the water. The strength of the electrical conductance depends on the concentrations of all dissolved ionic substances (“electrolytes”) in the water. The cations Ca2+, Mg2+, Na+, and K+ and the anions HCO3-, CO32-, SO42-, and Cl- normally dominate the ionic composition in undisturbed streams and rivers world-wide.

Dissolved solids are very strongly correlated with specific conductance in the West Virginia data set.
Like alkalinity, TDS appears to enter streams and rivers through baseflows.

NOTE: Temperature influences conductivity, so conductance measurements are adjusted to a common temperature (25oC) for comparison purposes.

Report Findings

- Can long-term trends be identified?
  Yes
- Does flow-adjustment strengthen trend detection?
  Not in this study's long-term (43-year) or short-term (17-year) trend periods.
- Are there regional trend patterns?
  Yes for some key parameters
- Can large-scale patterns be explained?
  Logical reasons can be suggested
  Site-specific analysis needed to confirm explanations

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Can long-term trends be identified? Yes
Approximately 74% of possible tests for long-term trends and 35% of possible tests for short-term trends were significant ($p<0.05$) or showing strong directional tendencies ($0.05<p<0.10$).

Does flow-adjustment strengthen trend detection? Not in this study's two trend periods.
Comparisons of flow-adjusted and unadjusted trends showed no overall difference in trend strength. Trends were conclusively different in only 21 of a possible 503 trend comparisons (9 long-term; 12 short-term). At least 12 of the 21 divergent results could be due to incomplete flow records.

Are there regional trend patterns?
Yes for some key parameters.
Also - trends in the Ridge and Valley ecoregion, on the eastern edge of the state, tend to do things differently than those in the central and western portions of the state.

Can we explain those patterns?
Despite many state-wide trends, trend explanations for individual stations can differ because causes differ.

More Report Findings

Long-term trends show mostly "good news"

- pH increasing (H^+ decreasing) – rivers and streams are less acid
- greater buffering capacity in the more acidic rivers
- dissolved metal concentrations are going down
- sediments and phosphorus concentrations are going down – probably for different reasons
- dissolved oxygen is trending upward

Of concern

- upward trends in specific conductivity and total dissolved solids
- high pollutant concentrations still present in mining regions

Chesapeake Bay Barometer (WQ)